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Paper

A Whole Body Counting Facility in a Remote Enewetak Island Setting

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***Abstract* - The U.S. Department of Energy (DOE) has recently implemented a series of strategic initiatives to address long-term radiological surveillance needs at former US test sites in the Marshall Islands. The plan is to engage local atoll communities in developing shared responsibilities for implementing radiation protection programs for resettled and resettling populations. As part of this new initiative, DOE agreed to design and construct a radiological laboratory on Enewetak Island, and help develop the necessary local resources to maintain and operate the facility. This cooperative effort was formalized in August 2000 between the DOE, the Republic of the Marshall Islands (RMI), and the Enewetak/Ujelang Local Atoll Government (EULGOV). The laboratory facility was completed in May 2001. The laboratory incorporates both a permanent whole body counting (WBC) system to assess internal exposures to ^{137}Cs, and clean living space for people providing 24-h void urine samples. DOE continues to provide on-going technical assistance, training, and data quality review while EULGOV provides manpower and infrastructure development to sustain facility operations on a full-time basis. This paper will detail the special construction, transportation and installation issues in establishing a whole body counting facility in an isolated, harsh environmental setting.**

Key Words: Marshall Islands, Enewetak Radiological Facility, WBC, ^{137}Cs

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Introduction

Enewetak Atoll is located in the remote northwestern corner of the Marshall Islands, some 2700 miles west of Hawaii (Fig.1).

Immediately after WWII, the United States created a Joint Task Force to develop a nuclear weapons testing program. Planners examined a number of possible locations in the Atlantic, the Caribbean, and the Pacific but decided that coral atolls in the northern Marshall Islands offered the best advantages of stable weather conditions, fewest inhabitants to relocate, and isolation with hundreds of miles open ocean to the west where trade winds were likely to disperse radioactive fallout. After an initial series of tests on Bikini Atoll in 1946, local inhabitants of Enewetak were moved to a new home on Ujelang Atoll in December 1947 in preparation for the scheduling of the first nuclear test on Enewetak in 1948 (Micronesian Support Committee). By the time the test moratorium came into effect in 1958, the United States had conducted a total of 43 tests on Enewetak Atoll. The atoll continued to be used for defense programs until the start of a cleanup and rehabilitation program in 1977. The people of Enewetak remained on Ujelang Atoll until resettlement of Enewetak Island in 1980. Since 1972, the Department of Energy has conducted a number of scientific missions to Enewetak and published a number of reports on radiation exposure in the Enewetak population. (Robison et al. 1973; Robison et al. 1980; Robison et al. 1987; Robison et al. 1998, Sun et al. 1997). The permanent resident population of Enewetak Atoll now total over 800 with most people living on Enewetak Island in the south where residual levels of fallout contamination are very low. Dose estimates based on environmental data as well as periodic WBC monitoring data supplied by the Brookhaven National Laboratory indicate internal radiation doses from fallout radionuclides (mostly ^{137}Cs) are decreasing with time, and that the present day effective dose rates are well below what could be reasonably considered harmful to human health (Sun et. al., 1997). Despite of these assurances, the local community has developed a societal fear of radiation, and has consistently expressed concerns about the increased risk of radiation exposure living on the island. There has also been lasting concerns about the radiological safety of using the northern reaches of the lagoon for food gathering and fishing. In August, 2000, the DOE responded with a new initiative. A Memorandum of Understanding (MOU) was developed in cooperation with the Enewetak/Ujelang Local Atoll Government (EULGOV) and the Republic of the Marshall Islands. The DOE agreed to provide funding for a dedicated facility on Enewetak Island to house a permanent whole body counter, contribute to the salaries to pay local technicians to operate the facility, and analyze a representative number of urine samples for plutonium using advanced accelerator mass spectrometric technologies available at LLNL.

Special Facility Construction

The selection of a building type that could withstand high exterior temperatures and yet be able to maintain a constant air-conditioned interior was a particular challenge. Fortunately, the United States Army Kwajalein Atoll Command (USAKA) had just begun installation of new officer living quarters utilizing an igloo type fiberglass double wall insulated structure that met these specifications. This type of structure is also contoured to help reduce damage from high winds in the case of a typhoon. Thus, the “Kwajalein igloo’ served as the prototype for the pre-fabricated building purchased for Enewetak Atoll. All the materials for the building had to be purchased in the United States and shipped to Kwajalein in two (2) 40 ft. containers. A vessel, contracted locally in the Marshall Islands, delivered the unassembled structure, equipment, and construction materials to Enewetak in October 2000.

A building site was chosen at the far northern end of island in a low background environment but in reasonable proximity to existing infrastructure (e.g., electrical generators and reverse osmosis water plant). At the same time, some attention was given to siting the building away from obvious sources of natural background radiation such as fuel storage tanks. Transporting all the building materials to this remote island location about 300 km from Kwajalein resulted in a logistics cost of about $137,000.

During construction, each modular shell section had to be secured to the adjoining section with hundreds of bolts. A concrete foundation laid down inside the building to support the weight of the whole body counter also provided additional anchor support for individual sections dovetailing into the concrete. Special internal scaffolding, provided by the manufacturer for this type of structure, was used and proved invaluable in the initial stages of assembly. The structural shell was assembled within a 4-week period during December 2000 (Fig. 2).

An additional $130,000 was required to complete the interior design of the building, purchase appliances and provide amenities; $50,000 for all the WBC detectors, associated electronics and computers; and a planned expenditure of $18,000 for purchase and installation of a satellite communication system. Electrical power and water are supplied through the local Enewetak Field Station. However, DOE agreed to augment existing electrical generator capacity on Enewetak Island with a new 125-kilowatt unit to help ensure a sufficient supply of electricity to meet the full and continuous requirements of the facility. DOE will slowly recuperate costs of the generator as power and water are supplied on a reimbursable rate. The full laboratory facility includes a bathroom and shower, washer and dryer, a fully equipped kitchen, laboratory space with fume hood, and sleeping quarters to accommodate for up to 8 people during an overnight stay to collect urine samples in a clean, contamination-free environment.

The total cost of the whole facility including the whole body counting equipment was approximately $335,000. This included all the transportation costs of shipping equipment, building materials and supplies to Enewetak. The building was formally opened at a dedication service held on May 9, 2001 (Fig. 3) and has been fully operational as a WBC facility since May 29, 2001.

Whole Body Counter

The Whole Body Counter (WBC) installed on Enewetak Island is designed to be operated with a Sodium Iodide (NaI) detector that will detect small quantities of high-energy gamma emitting radionuclides. The NaI detector is a 28 cm diameter 10 cm thick solid crystal and is very delicate. The NaI is housed inside a 4.8-cm thick shield that can be rotated to allow for the maximum observation of the entire body. A Canberra Inspector and associated whole body counting software specifically designed for the NaI detector is interfaced to a desktop computer.

The whole body counter includes a lead core shadow shielded chair that was refurbished and transported to Enewetak Island on a small boat. The patient sits inside the shadow-shielded enclosure on a chair that can be adjusted back and forth to assure the proper counting distance. This design of whole body counter is typically referred to as a Masse-Bolton Chair design (Masse and Bolton, 1970). The Masse-Bolton Chair design is sufficient to monitor for radionuclides in most of the body and all of the internal organs. The back of the chair can be adjusted to be 350 to 500 cm from the detector. The positioning of the patient will nominally achieve a 300 to 350 cm arch along the midline of the sitting patient. Positioning the patient (i.e., distance of the midline of the patient to the detector) is important if accurate and repeatable results are to be obtained. Calibration of the system is performed using a Bottle Man-akin Absorption (BOMAB) phantom filled with a known amount of mixed gamma emitting radionuclides (Fig.4.)

The final assembly, calibration and operational readiness of the whole body counting system were completed by LLNL scientists during an on-site visit in late May, 2001. Immediately prior to the scientific mission, two local WBC technicians received six weeks of specialized training at the LLNL focusing on basic radiological worker training and whole body counting. All aspects of the routine WBC monitoring program are controlled by the local technicians using documented procedures. However, LLNL scientists continue to play an integral part in the process by providing advanced training for technicians, helping with systems maintenance and trouble shooting, and data quality assurance. Advanced plans have been made of DOE, in conjunction with the Republic of the Marshall Island's National Telecommunication Authority, to purchase and install a state-of-the-art satellite communication system at the Enewetak laboratory, to support scientific work. The system will have phone, fax and data-transfer capabilities that, among other things, will enable technicians and LLNL personnel to perform real-time diagnostics on the computer equipment and improve quality controls.

Quality Assurance Measures and Data Management

Local Marshallese whole body counting technicians are responsible for all daily operations in the WBC facility while scientists from the Lawrence Livermore National Laboratory (LLNL) provide on-going technical assistance, training, and quality review. Each volunteer receives a preliminary written report (in Marshallese and/or English as needed) from the WBC technician immediately after counting. The preliminary report shows the total amount of ^{137}Cs and naturally occurring ^{40}K detected, and gives an estimated annual dose based on a chronic intake.

The WBC electronic database files are backed up on transportable disc media, and forwarded to LLNL with hardcopy documentation for quality assurance review (Fig. 5).

The daily background counts, standard source checks, and personal counts are loaded into a mirror computer system at LLNL. The information is carefully reviewed by program personnel to assure compliance with control limits and validate database information with paper records. Count results are checked against established data quality assurance objectives to assure that results are reasonable relative to other known environmental levels and historical measurements obtained from the Marshall Islands program. The accepted data are exported into an ASCII comma delimited file, the data import is verified and sorted, and a secondary level of quality assurance performed on the data before its placed into a permanent Access 2000 (MS Project) database. At the same time, the original and a copy of WBC report are stamped as having passed QA–the final stamped copy of the report is returned to the individuals concerned using the postal service. The non-accepted data are moved into an unresolved listing for further review. Attempts are made to resolve outstanding quality assurance issues by satellite communication, radio-patch and/or distribution of written procedures to the WBC technicians in the field. Any data that is resolved enters back into the data quality assurance stream otherwise the count is rejected. Updates to the Access 2000 database are forwarded to DOE on a quarterly basis, and the information made publicly available on the World Wide Web. A summary of individual whole body counting results and their relationship to the minimum detectable level of ~ 0.06 kBq is provided in (Fig. 6).

Conclusions

The completion by DOE of the Enewetak Radiological Facility on Enewetak Island in the Marshall Islands represents a unique logistic undertaking. Transportation of the specially designed structure to such a remote setting and its fabrication was a real challenge. Equipping the facility with modern state-of-the-art whole body counting detectors, equipment, computers, and satellite communication capabilities represented a carefully planned and executed process. Equipment installed had to be able to operate under harsh environmental conditions and be operable by trained local Enewetak community technicians. This effort was a collective effort that involved DOE planning, LLNL supervision and oversight, superior efforts of the DOE logistical contractor (Bechtel Nevada) including transportation, facility assembly, completion of the interior and support amenities, and the cooperation and help of the Enewetak community. The lessons learned from this project can be of use to others who are considering how to set up distantly operated technical facilities, in other remote world settings. Installation of a reliable consistent supply of electrical power for the whole body counting and computer support equipment, HEPA-filtered air-conditioning and general facility operation was of paramount importance to the successful implementation of a whole body counting capability on Enewetak Island on a year-around basis. A source of fresh water required the installation of a reverse osmosis (R/O) unit to process nearby seawater. The Enewetak community is proud of its new radiological facility and the meaningful involvement of its own, trained citizens. The community sense of pride helps with the continued operation and maintenance of the facility and facilitates improved communications and cooperation with DOE counterparts. The monitoring capability it provides for local Enewetak inhabitants provides assurance that environmental doses from ingestion of ^{137}Cs and naturally occurring ^{40}K in locally grown foods remains at low levels that impose no health risk.

Acknowledgment

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References

Masse, F. X.; Bolton, M. M. Jr.
Experience with a low-cost chair-type detector system for determination of radioactive body burdens of M.I.T. radiation workers. Health Phys. 19(1): 27-35, 1970.

Micronesian Support Committee, Marshall Islands, A Chronology: 1944-1981) Washington DC Library UF 890.M35 C.

Robison, W. L. Dose estimates for the marine food chain. In: Enewetak radiological survey. Las Vegas; U.S. Atomic Energy Commission, Nevada Operations Office; NVO-140, Vol. 1; 1973: 526-541.

Robison, W. L.; Phillips, W. A, Mount, M. E.; Clegg, B. R.; Conrado, C. L. Reassessment of the potential radiological doses for residents resettling Enewetak Atoll, Lawrence Livermore National Laboratory, UCRL-53066, 1980.

Robison, W. L.; Conrado, C. L.; Phillips, W. A. Engebi Island Dose Assessment. Livermore, CA. Lawrence Livermore National Laboratory; URCL-53805; 1987.

Robison, W. L.; Noshkin, V. E. Radionuclide characterization and associated dose from long-lived radionuclides in close-in fallout delivered to the marine environment at Bikini and Enewetak Atolls. Livermore CA. Lawrence Livermore National Laboratory; UCRL-JC-130230; 1998.

Sun, L. C.; Clinton, J. H.; Kaplan, E. Meinhold, C.B. ^{137}Cs exposure in the Marshallese populations: An assessment based on whole-body counting measurements (1989 – 1994). Health Phys. 73(1): 86-99: 1997.

Sun, L. C.; Meinhold, C. B.; Moorthy, A. R.; Kaplan, E., and Baum, J. W. Assessment of plutonium exposure in the Enewetak population by urinalysis. Health Phys. 73(1): 127-132; 1997.

Figure 1. Map of the Marshall Islands atolls showing Enewetak Atoll at the upper left.
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Figure 2. Construction of the modular shell sections utilizing internal scaffolding.
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Figure 3. The newly constructed radiological facility on Enewetak Island – this "igloo design is a low maintenance facility ideally suited to withstanding high wind and harsh sea salt environments.
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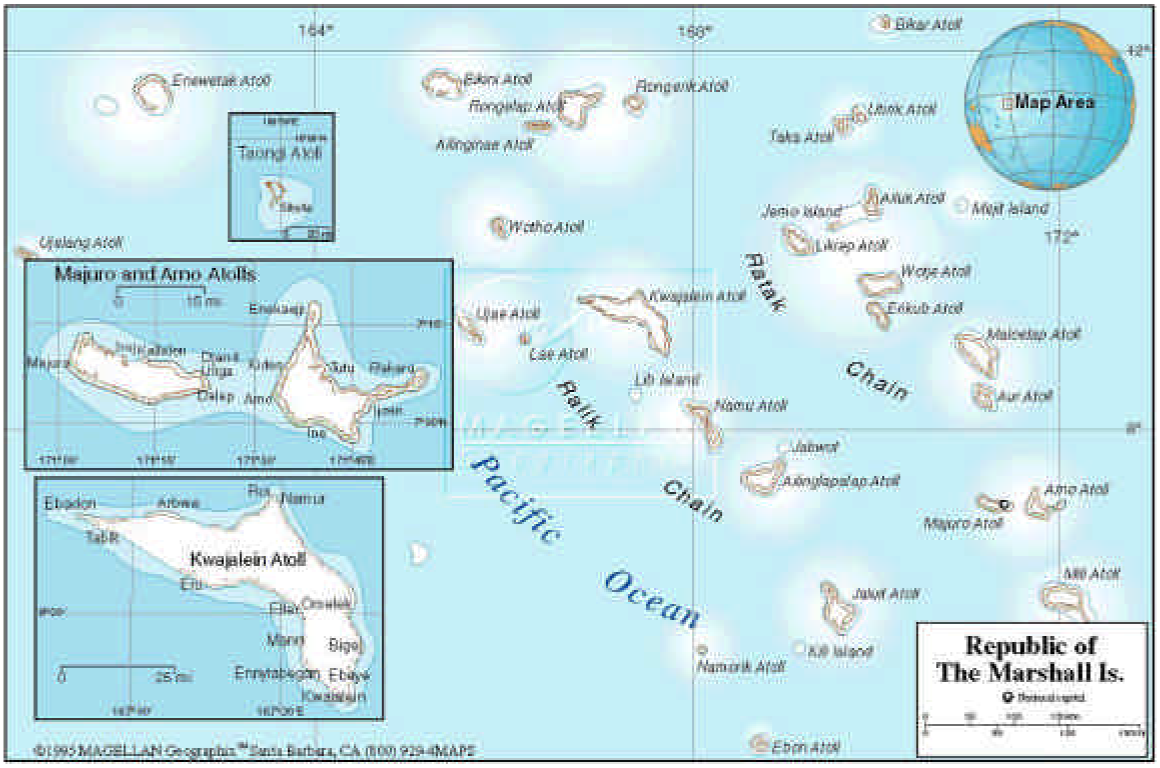
Figure 4. Bottle Man-akin Absorption (BOMAB) calibration phantom seated in a whole body counting chair.
File: "WBC Chair with Calibrator.jpg"

Figure 5. Schematic outline of the WBC Quality Assurance Plan (WAP).
File: "WBC_flowchartcopy.jpg

Figure 6. Whole body burdens detected (kBq) in the resident population using locally operated WBC technicians.
File: "Enewetak rad lab wbc copy.jpg"



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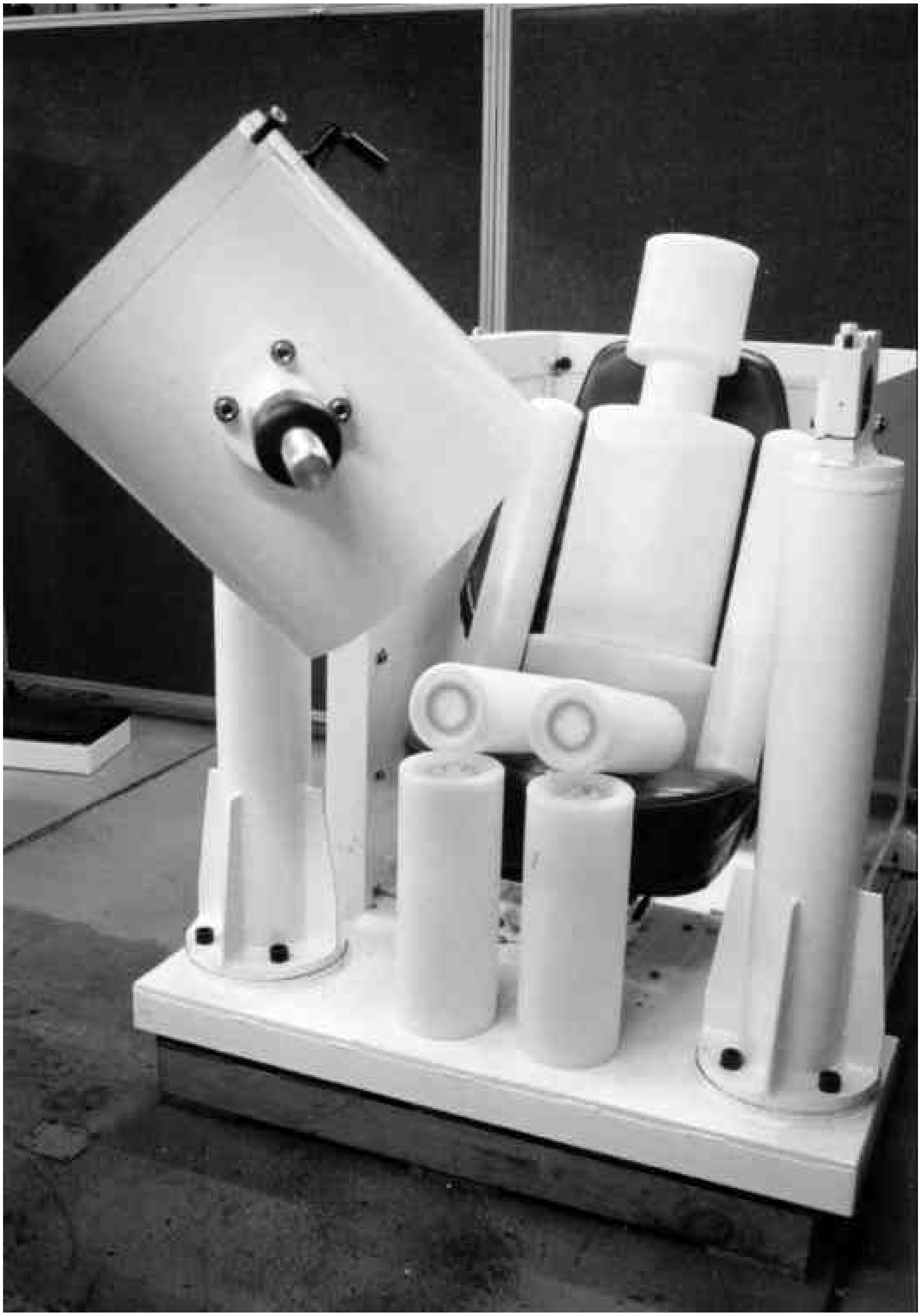

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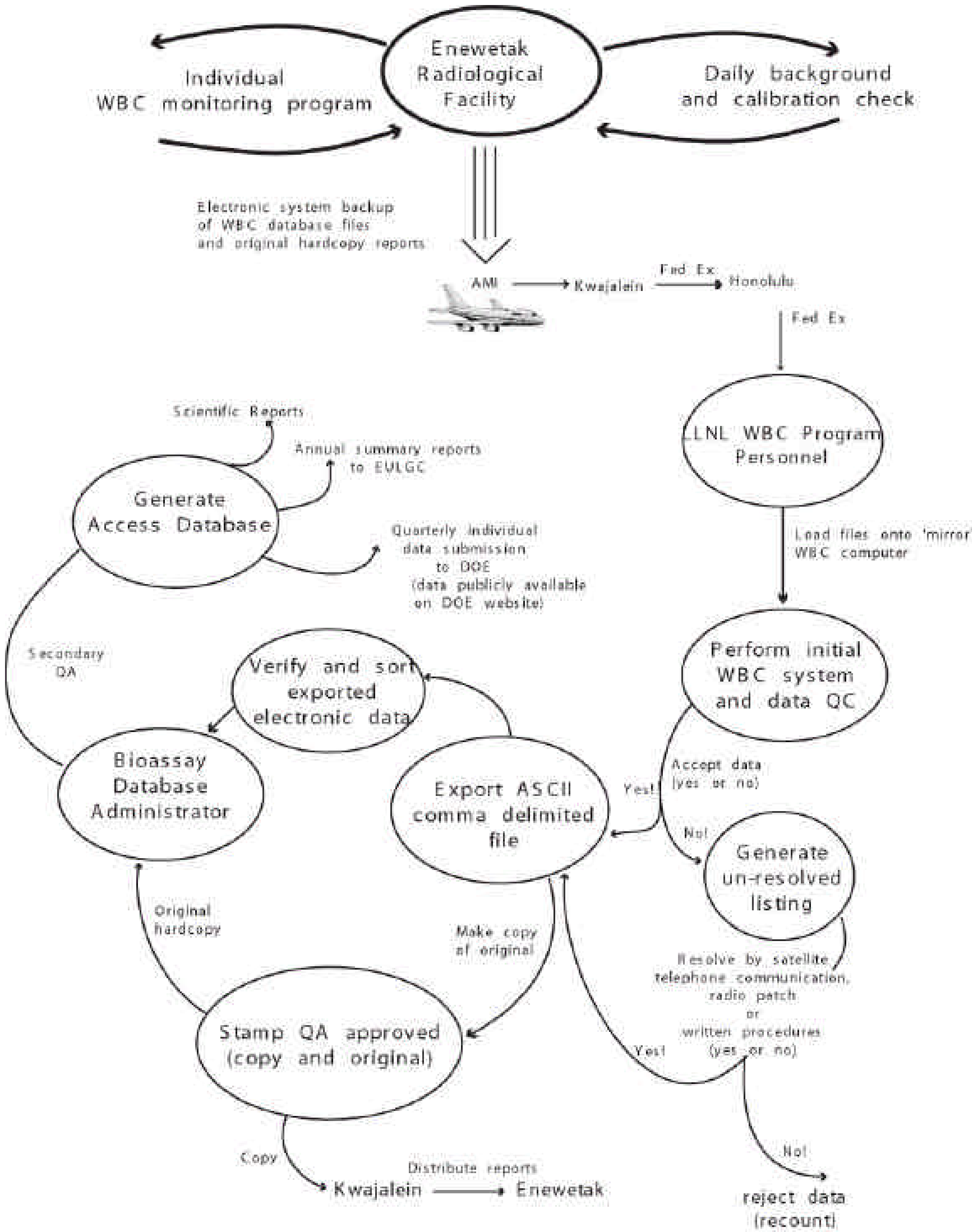

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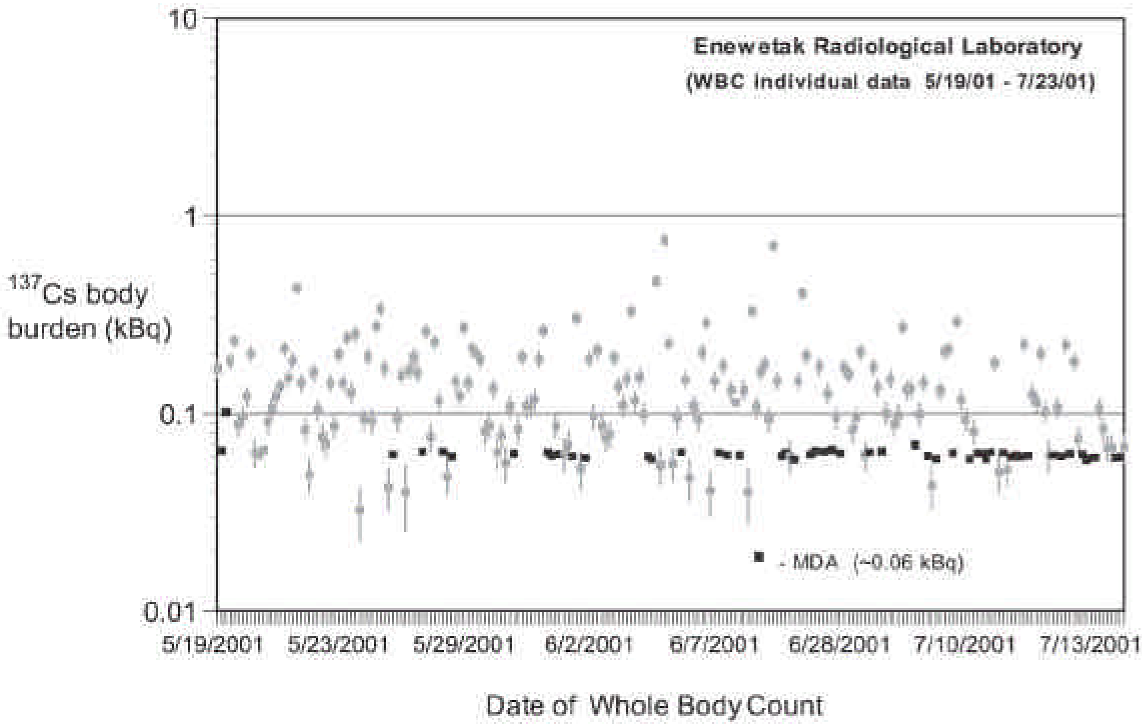

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